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<b>UTILITY PATENT APPLICATION TRANSMITTAL</b>		Attorney Docket No. <b>2447-012</b>
First Inventor or Application Identifier <b>COHEN, Lawrence T.</b>		
Title <b>Electrode Array with Non-Uniform Electrode Spacing</b>		
Express Mail Label No. <b>FI 1703992601 IS</b>		

<b>APPLICATION ELEMENTS</b> See MPEP chapter 600 concerning utility patent application contents.		<b>ADDRESS TO:</b> Assistant Commissioner for Patents Box Patent Application Washington, DC 20231	
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- Cross References to Related Applications	b. <input type="checkbox"/> Paper Copy (identical to computer copy)		
- Statement Regarding Fed sponsored R & D	c. <input type="checkbox"/> Statement verifying identity of above copies		
- Reference to Microfiche Appendix			
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- Brief Summary of the Invention			
- Brief Description of the Drawings (if filed)			
- Detailed Description			
- Claim(s)			
- Abstract of the Disclosure			
3. <input checked="" type="checkbox"/> Drawing(s) (35 U.S.C. 113) [Total Sheets <b>2</b> ]	<b>ACCOMPANYING APPLICATION PARTS</b>		
4. Oath or Declaration [Total Pages <b>1</b> ]	7. <input type="checkbox"/> Assignment Papers (cover sheet & document(s))		
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### Complete if Known

Application Number	To Be Assigned
Filing Date	Herewith
First Named Inventor	COHEN, Lawrence T.
Examiner Name	To Be Assigned
Group / Art Unit	To Be Assigned
Attorney Docket No.	2447-012

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106 310 206 155		Design filing fee	
107 480 207 240		Plant filing fee	
108 690 208 345		Reissue filing fee	
114 150 214 75		Provisional filing fee	
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Total Claims	Extra Claims	Fee from below	Fee Paid
13	20** = 0	X	
Independent Claims	2 - 3** = 0	X	
Multiple Dependent			

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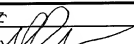
Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
103 18 203 9		Claims in excess of 20	
102 78 202 39		Independent claims in excess of 3	
104 260 204 130		Multiple dependent claim, if not paid	
109 78 209 39		** Reissue independent claims over original patent	
110 18 210 9		** Reissue claims in excess of 20 and over original patent	
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105 130 205 65		Surcharge - late filing fee or oath	
127 50 227 25		Surcharge - late provisional filing fee or cover sheet	
139 130 139 130		Non-English specification	
147 2,520 147 2,520		For filing a request for reexamination	
112 920* 112 920*		Requesting publication of SIR prior to Examiner action	
113 1,840* 113 1,840*		Requesting publication of SIR after Examiner action	
115 110 215 55		Extension for reply within first month	
116 380 216 190		Extension for reply within second month	
117 870 217 435		Extension for reply within third month	
118 1,360 218 680		Extension for reply within fourth month	
128 1,850 228 925		Extension for reply within fifth month	
119 300 219 150		Notice of Appeal	
120 300 220 150		Filing a brief in support of an appeal	
121 260 221 130		Request for oral hearing	
138 1,510 138 1,510		Petition to institute a public use proceeding	
140 110 240 55		Petition to revive - unavoidable	
141 1,210 241 605		Petition to revive - unintentional	
142 1,210 242 605		Utility issue fee (or reissue)	
143 430 243 215		Design issue fee	
144 580 244 290		Plant issue fee	
122 130 122 130		Petitions to the Commissioner	
123 50 123 50		Petitions related to provisional applications	
126 240 126 240		Submission of Information Disclosure Stmt	
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146 690 246 345		Filing a submission after final rejection (37 CFR § 1.129(a))	
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### SUBMITTED BY

Name (Print/Type) Tiberiu WEISZ  
Signature 

Registration No. (Attorney/Agent) 29,876

### Complete (if applicable)

Telephone 212 684 3900  
Date August 28, 2000

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**Inventor(s):**

**COHEN, Lawrence T.**

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**ELECTRODE ARRAY WITH NON-UNIFORM  
ELECTRODE SPACING**

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**CERTIFICATE OF EXPRESS MAIL UNDER 37 CFR §1.10**

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### Technical Field

## Background Art

- ## 30 Summary of the Invention

## 30 Summary of the Invention

Broadly, the present invention provides an electrode array in which the electrodes are not evenly spaced, but rather are differentially spaced in order to better target selected regions of the cochlea.

According to one aspect, the present invention provides an  
5 intracochlear electrode array in which the electrodes are closer together at the apical end of the array. This may be achieved in various ways – for example, by a uniformly graduated change in spacing, or by selecting two or more regions of the electrode array to have different spacings.

This aspect of the invention is based on several factors. It has been  
10 determined that it is desirable for the spacing of electrodes to correspond to uniform intervals along the organ of Corti. While audio stimulation receptors on the outer wall of the scala tympani are generally regularly spaced, receptors on the inner wall tend to be spaced closer together the further one travels inwardly. It has been determined that receptors on the inner wall of the  
15 scala tympani are more sensitive than those on the outer wall, and it would therefore be more effective to stimulate these inner receptors rather than the outer ones as is traditionally done. Preferably, the electrode spacing should be determined by the intercepts, along the intended array placement, of lines passing from a modiolar centre point through points spaced at equal  
20 increments along the organ of Corti. This arrangement generally maximises the uniformity of spectral coverage for a given number of electrodes, and accordingly the probability of good speech perception by an implant recipient.

According to another aspect, the present invention provides an  
25 electrode array with the spacing of electrodes varied so as to provide a higher density of electrodes at specific regions – for example, along a part of the array intended to stimulate one or more regions of the neural structures corresponding to frequency bands which are considered particularly important for speech recognition. This could be based on many different considerations – the essence of this aspect of the invention is simply to provide electrodes at  
30 reduced spacing in areas of particular interest.

### Brief Description of the Drawings

The invention will now be described with reference to the accompanying figures, in which:

- Figure 1 is a schematic illustration of a conventional electrode array in a scala tympani; and  
 Figure 2 is a schematic illustration of an electrode array with non-uniform spacing of electrodes.

Referring to figure 1, this is based upon an X-Ray of an implanted device having a curved configuration, for example an array according to PCT/AU99/00391 by Cochlear Limited. It will be appreciated that this is a sectional view showing the scala tympani 10, which in fact curves into the page, but for present purposes the invention can be explained with reference to a two dimensioned projection.

Dotted line 15 represents the organ of Corti, on which the audio receptors 12 are disposed at the intersection of radial lines 11 (only one thus labeled) and the organ of Corti 15. Radial lines 11 are shown extending from the modiolar centre 16, and are of course, purely represented for the purpose of illustrating the present inventive concept. Receptors 12 are composed of neural structures, including spiral ganglion cells, which extend radially inward from the organ of Corti 15. It is in fact these cells which are stimulated by the stimuli produced by electrodes in a cochlear implant.

It will be noted that receptors 12 are disposed at equal intervals along the organ of Corti 15 (at critical bands), even as the curvature increases as the cochlea spirals inwards. The most effective stimulation of these receptors is achieved by direct stimulation by electrodes, and so cochlear implants have been traditionally constructed with electrodes spaced equally to correspond with the spacing of these critical bands. These electrodes are shown as elements 13 on cochlear implant 14.

It has been determined that receptors are more sensitive on the inner wall 18 of the scala tympani 10. Accordingly, it has been found that a better result is achieved by a cochlear implant having electrodes stimulating receptors on the inner wall. To achieve this, the electrodes are caused to lie

against the inner wall 18, to make contact with receptors 17 (lying on the intersection of radial lines 11 and the inner wall 18 of scala tympani 10).

As can be seen in figure 2, the receptors 17 on the inner wall 18, are spaced more and more closely together, as they approach the centre of the spiral of the cochlea. Thus, to maintain effective stimulation contact with receptors 17, electrodes 13 of the electrode array 14 are spaced with decreasing separation to each other the closer they approach the apical end of the electrode array 14.

Therefore, with an understanding of the physiology and geometry of the cochlea together with an understanding of the tonotopical nature of the cochlea, an electrode array can be designed to improve the fidelity of the reproduction of the audio spectrum in the percept of the cochlear implant recipient. This can be done by arranging the placement of the electrodes along the electrode array such that the spectral coverage of the electrodes are maximised to ensure optimum stimulation of the cochlea is achieved.

It will be appreciated that in the application of the present invention, the excitation by the electrodes is assumed to be substantially radial.

It may also be desired to take into account two further effects. The structures are considerably more complex than is apparent from the schematics. At the basal end of the scala tympani, the organ of Corti lies closer to the inner wall 18 and the spacing of the most basal electrodes could be reduced to take account of this. At the apical end, there is a greater angular offset between the organ of Corti 15 and the underlying cell bodies, and again the spacing could be adjusted to account for this effect.

It will be appreciated by those skilled in the art that the present invention can be readily manufactured by existing techniques, and could be of any desired electrode geometry or cross-sectional shape. The present invention is concerned with the spacing of the electrodes, not their construction.

**CLAIMS:**

1. An electrode array for use in a cochlear implant, said electrode array having electrodes selectively positioned along said electrode array in order to better target selected regions of the cochlea.
2. An electrode array according to claim 1 wherein the spacing between adjacent electrodes is less at an apical end of the electrode array than at a basal end.
3. An electrode array according to claim 1 or 2, wherein one region of the electrode array has electrodes which are spaced from each other differently to electrodes from at least one other region of said electrode array.
4. An electrode array according to claim 1 or 2 wherein the spacing between consecutive electrodes is uniformly graduated.
5. An electrode array according to claim 3 or 4 wherein said spacing between adjacent electrodes is such as to correspond closely with the spacing of auditory receptors on the inner wall of the scala tympani.
6. A method of constructing a cochlear electrode array for implantation into a cochlea of the patient as part of a cochlear implant system, the method including:
  - a. determining the regions of the cochlea where stimulation is desired; and
  - b. positioning the electrodes along the electrode array in a location or locations that will enable stimulation of the desired site of the cochlea when the electrode array has been inserted.



7. A method according to claim 6 wherein the step of positioning the electrodes includes positioning the electrodes such that the spacing between adjacent electrodes is less at the apical end of the electrode array than at the basilar end.
8. A method according to claim 6 wherein the step of positioning the electrodes including positioning the electrodes such that the spacing between adjacent electrodes differs in differing regions along the electrode array.
9. A method according to claim 6 or 7 wherein the step of positioning the electrodes including positioning the electrodes such that the spacing between consecutive electrodes is uniformly graduated.

**ABSTRACT**

An electrode array for use with a cochlear implant is disclosed, which has electrodes selectively spaced to better target selected regions of the cochlea. In one form, the spacing between adjacent electrodes decreases  
5 towards an apical end of the array allowing the electrodes to better target receptors on the inner wall of the scala timpani of the cochlea.

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Fig 1.



Fig 2.

